APPENDIX E

DEFINING CHOICES AND IDENTIFYING DRIVERS OF SPECIES INTRODUCTIONS

ECONOMICS

discussion date: January 11, 2012

Sometimes it takes a different perspective to see a solution to a problem. While conservation managers, researchers, homeowners, policy specialists, businesses and others work to reduce the harm from invasive species, it's worth asking if there are lessons that could be learned by looking at the impact of invasive species and invasive species management through the lens of economics. Which actions should be prioritized for funding? Do we choose prevention efforts or the control of species that are already causing harm? How should limited resources be distributed between control efforts? Economics can offer a different view on policy options for addressing the less tractable invasive species issues such as prioritization and incentivizing behaviors that avoid spreading invasive species.

The cost of managing invasive species is well documented. In a 2005 update to his comprehensive 2000 paper, David Pimentel reconsidered the economic costs of invasive species in the United States to be about $120 billion per year. The biodiversity of North America is changing as well, and while harder to value, an alarming 42% of the listed Threatened or Endangered species are at risk due to invasive species competition, predation or alterations to their ecosystems. The scale of the issue requires serious attention and perhaps a more creative and inclusive approach than has been tried.

The topics that follow in this summary identify the scale of the harm caused by invasive species in Wisconsin and the level of resources needed to address the impacts. One problem highlighted by these talks is the disparity of who covers the costs resulting from an invasive species introduction. For example, if steps are not taken to prevent invasive species introductions associated with imports from occurring and new invasive species establish, the consequences are borne by the recipients, not the exporters. The costs to reduce the harm caused by the invasive species are typically much greater and more wisely distributed than the cost to apply treatments to reduce risk. One interesting area for further discussion will be to include invasive species in the calculation when calculating whether or not it is worth the price to import goods or develop local and less risky sources.

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OVERVIEW: The economics of invasive species and how economic questions are framed

Bill Walker, *Wisconsin Department of Natural Resources*

To open the discussion on how economists view invasive species start with a thought problem: there are two countries, Us and Them. If they open up trade and a native species moves from Us to Them and negatively impacts local agriculture, is the net effect positive or negative? The correct answer is we don't have enough information to know. The positive impacts of trade may or may not outweigh the negative impacts of the invasive species.

Economics as a science can help to answer the following questions*:

- What are the effects of invasive species?
- What is the right effort level in response?
- How does one organize a response?

**Caution: economics may not give you the answer you want.*

Economics allows for responses to invasive species to be optimized. Once a biological target is set the solution on how to achieve that target can be left up to the market. If a shipper is given the responsibility to inspect there should be an incentive (or disincentive for not doing the action) to carry out the inspections but there are many tools to address this.

An example of this type of policy and response may be Asian Gypsy Moth. As soon as a ship is identified with moths the ship is sent to sea. The incentive has been moved to the shipper to identify and remove all egg masses but does not specify how that should be done.

In general, be aware that dollar amounts in economic studies are contextual and may not apply more broadly. Research specifically on invasive species is sparse compared to the literature on environmental economics. The studies that are available have a narrow focus. Big studies don't exist on invasive species. While it may not be worthwhile to hope for better research in the short term, do aim for better policy options by using an economic approach.

CASE STUDY: Export value of Wisconsin crops and the potential cost of new pests and diseases

Duane Maatz, *Wisconsin Potato & Vegetable Growers Association*

The Wisconsin Potato & Vegetable Growers Association focuses on initiatives in research, grower education and communication. The approach to invasive species has been to develop an integrated pest management strategy specific to potatoes and encourage prevention of pests that could lead to trade sanctions.

Statewide, there are 200-240,000 acres of irrigated vegetable farms that produce about $300 million in farm level revenue (Table 3). Currently, Wisconsin plants about 62,000 acres of potatoes with 8000 acres in Langlade County alone. This places Wisconsin in 3rd place behind Idaho and Washington. When all of the value added components are included the value of these crops jumps to $9 billion. Wisconsin is the largest state user of the Foreign Agricultural Service "Market Access Program" funds that support promotion of agricultural products. This promotes about $750,000,000 in overseas sales including international aid with the Benelux potato producing and eating countries being the largest importers.

continued

TABLE 1. The total value of production taken from the February 24, 2012 US Department of Agriculture, National Agricultural Statistics Service summary of the 2011 Wisconsin Crop Values.

Dollars in $1000s	Value of Production		
Crop	**2009**	**2010**	**2011**
Principal Crops	3,485,970	4,736,850	*
Commercial Vegetables	198,773	152,691	212,954
Fruits and Nuts	215,932	211,150	*
Field and Misc. Crops	3,071,265	4,373,009	4,841,088
Corn	1,600,395	2,646,594	3,107,520
Soybeans	623,376	889,002	861,120
Oats	24,398	22,579	23,886
Barley	4,101	3,528	3,067
Winter Wheat	88,250	78,016	133,916
Alfalfa Hay	410,750	399,620	357,420
Other Hay	44,400	58,212	68,828
Dry Beans	5,004	4,921	6,270
All Potatoes	256,473	257,506	262,500
Maple Syrup 2/	7,340	4,622	-
Peppermint Oil	2,613	3,776	5,061
Spearmint Oil	428	491	299

*Total value of production will be published in 2013. 2/2011 estimate published in the June 2012 Crop Production report.
Source: USDA, NASS, WI FO. See source: **http://www.nass.usda.gov/Statistics_by_State/Wisconsin/Publications/Crops/cpvalue.pdf**

Significant pests that are not yet in Wisconsin include golden cyst nematodes *Globodera rostochiensis* (found in New York) and pale cyst nematodes *G. pallida* (found in Idaho) which both move in soil. The introduction of these pests was likely with the transfer of heavy equipment returned to the US from Europe after WWII from decommissioned equipment. These pests may take decades to establish significant populations but can be devastating to the crops when they are abundant requiring a switch to resistant varieties or long crop rotation schedules.

Pest free countries refuse to accept infested potatoes and any export from the US increases domestic value. The presence of quarantine pests has led to the establishment of trade sanctions on all products. Sanctions may even impact prepared products without careful negotiations. It is important to prevent the introduction of these species to Wisconsin and maintain surveillance for these pests. Based on Idaho's experience the value of the crop is cut in half, machinery must be disinfected prior to being moved between fields and this can damage GPS and other tractor's equipment. Any soil movement is affected even if other crops are grown.

Even before these species become established there is a significant cost. Wisconsin and other states send their samples for identification to Idaho. Locally 8000 acres in Wisconsin must be tested adding $320,000 for soil testing. This is a voluntary and has low participation due to the cost and disincentives if the pests are found. The risk of introduction is ongoing as growers tend to diversify their seed potato sources. Soil fumigants are available to help reduce the symptoms of some pests but total decontamination is not possible. The North American Plant Protection Organization supports efforts to identify and stop off shore pest movement and help look for overseas solutions. A longer term strategy is to breed resistant potato varieties. This has a small national research budget of about $600,000 and has not yet achieved results.

RESEARCH: Estimating the value of avoiding Eurasian Water Milfoil invasions

Bill Provencher, University of Wisconsin, Madison

The impacts of invasive species can be measured in many ways but from an economist's perspective the economic loss of a species invasion (to society, broadly defined) is measured as the foregone net benefits to consumers and producers. In the case of aquatic species invasions a substantial loss can accrue to lake users (boaters, shoreline property owners, other lake users).

Using the example of an aquatic species invasion, the economic loss to individual X of an invasion in lake Y is indicated by the answers to the following questions:

- "How much would individual X be willing to pay to eliminate the species from the lake?"
- "How much would individual X be willing to pay to prevent the species from entering the lake?"

The concept of willingness to pay reflects the individual's willingness to "give up other stuff" for an invasive-free lake; it reflects value in terms of opportunity cost. These values are not the same as lost tourism dollars.

So what does a Eurasian water milfoil invasion cost in the northern highlands lake district? We compared two estimates: one derived from a hedonic analysis and one obtained from a contingent valuation (CV) analysis.

The hedonic valuation of shoreline property prices was published by Horsch and Lewis (2009). They examined 1841 properties sold on Vilas County lakes in the period 1997-2006. This included 172 lakes, 17 of which had milfoil by 2006 and 9 on which milfoil was discovered during the study period. 161 properties sold on these 9 lakes. This study accounts for the fact that milfoil is not randomly applied to lakes, but rather may be associated with "unobservable" lake characteristics.

The Contingent Valuation (CV) analysis applied to prevention of a milfoil invasion on lakes without milfoil and control of milfoil on a lake already invaded. Two types of milfoil-related CV questions were asked: one for respondents on lakes that already have milfoil and one for respondents on lakes that did not have milfoil the previous summer. We gave respondents the following info:

- Consequences of milfoil on a lake
- Lake types that are most vulnerable
- Current status of milfoil in Vilas County
- Current status of milfoil on the respondent's lake according to the DNR

Ultimately, both approaches yielded similar results (Table 1).

TABLE 2. ESTIMATED WELFARE LOSS FROM A MILFOIL INVASION.

		Estimate	95% Low	95% High
Results of Horsch and Lewis Hedonic Valuation study:	Annual Loss	$1,270	$433	$2,107
	Capitalized Loss	$28,294	$9,656	$46,933
Results of Provencher *et al* for loss from milfoil invasion on lakes currently without milfoil, from CV prevention question	Annual Loss	$1,373	$776	$2,148
	Capitalized Loss	$30,550	$17,283	$47,884
Results of Provencher *et al* for gain controlling milfoil on lakes that currently have milfoil, from CV control question	Annual Loss	$1,521	$1,178	$2,318
	Capitalized Loss	$33,883	$26,242	$51,637

CASE STUDY: Striking a balance on sea lamprey control efforts in the Great Lakes

Jeff Slade, *U.S. Fish and Wildlife Service*

One of the most widely recognized aquatic invasive species in the region, sea lamprey moved into the Great Lakes via Welland Canal in 1919. By 1938 the species had moved to Lake Superior and the declines in fisheries were dramatic. Each adult sea lamprey can kill 20-24 lbs of fish as it feeds over its lifetime. Lake trout were extirpated from all lakes but Superior. The Great Lakes Fishery Commission was founded in 1955 to coordinate fisheries research, to recommend measures that permit maximum sustained productivity of fish stocks and to formulate and implement a program to eradicate or minimize sea lampreys. Research on control focused on the movement of sea lamprey to streams during spawning and larval phases.

Collecting larvae in streams was possible through electroshock methods. Surveys could assess the density of larvae in the more accessible streams rather than looking for adults in the open water of the Great Lakes. Spawning assessment using upstream traps was developed to identify the density of adults and estimate abundance on each of the Great Lakes. The search for an effective control finally identified chemicals that are relatively specific to lamprey larvae. Currently there are two pesticides that are selectively applied (TFM and Baylucide) and pumped into over 100 streams annually. There is a programmatic review of all activities and looks for potential impacts as this control continues.

The level of damage that the lamprey should be allowed to do to the Great Lakes fisheries is agreed on by the international fisheries commissions. The currently accepted level of damage on lake trout is set at 5 wounds per 100 lake trout. Information on the level of damage is collected directly from the catch by federal, tribal and state managers. The level of damage is translated into an estimate for the number of spawning sea lamprey and control is shifted to try to have all lakes meet target. This decision making process is separate from the results of the economic injury level (EIL) analysis. The EIL asks, "How much control do you apply before the cost to control exceeds the value for recovered resources gained by control?" The lamprey specific EIL applied to Great Lakes fisheries suggested a higher level of control.

Allocation of control dollars is even if all lakes are above target values. Resources for the control work have not been increased to match observed damage. The Great Lakes Fishery Commission is made up of four US appointees and four Canadian appointees and is responsible for the decision making on control efforts. In addition, four separate taskforces feed information from the field to the Sea Lamprey Research Board. The Sea Lamprey Integration Committee incorporates information from all of the sub-taskforces and synthesizes the information. Dr. Mike Hansen (UW Stevens Point) is chair of this committee. The level of damage and recommendation from the Sea Lamprey Integration Committee is made to the Commission for funding decisions. About $22,000,000 per year from both countries is invested in control. For reference, the fishery is worth $7,000,000,000 for both countries.

CASE STUDY: The cost and impacts of aquatic invasive species to municipal power and water suppliers

Paul Schumacher, *Wisconsin Invasive Species Council Chair*

Cities using surface water as a source of potable water or in the operation of electric utilities are potentially susceptible to the impacts from aquatic invasive species (AIS), especially the impacts from zebra and quagga mussels (*Dreissena* spp.). These invasive mussels attach to submerged, offshore water intake structures and the inside of pipelines and water treatment devices, causing reduced flow and in extreme cases, plugged pipelines.

Potable Water Systems

At least eighteen municipal potable water systems in Wisconsin use surface water as sources of raw water including thirteen which use Lake Michigan, three which use the Lake Winnebago/Fox River system and two which use Lake Superior. The cities included in this survey represent the majority of Wisconsin's population. Since zebra mussels have been present in these waters since the mid-1990's, cities have addressed potential pipeline fouling problems created by these mussels, and more recently by quagga mussels, through a combination of mechanical removal and chemical treatment (biocides).

Seven of the eighteen potable water systems susceptible to AIS were surveyed to develop an overview of control approaches and subsequent costs. Review of control approaches across the state shows that installation and use of biocide injection systems at the water intakes is the most common approach used to control both zebra and quagga mussels. Biocides used include various compounds containing chlorine or permanganate, both chemicals shown to prevent juvenile mussels from colonizing the surfaces of water systems. The biocide is injected at the water intake on a continuous or intermittent basis, depending upon the severity of the mussel fouling potential in the area. In addition, cities perform annual inspection of water intake systems and key facility components by divers and water treatment staff, respectively.

Individual facility control costs range widely, driven by location of water intake structures and local mussel fouling potentials. For example, water systems at shallower locations where AIS mussels are present in higher numbers generally have higher costs, and water intakes at deeper locations and/or locations where AIS mussels are present in lower numbers generally have lower costs.

Control costs include both the capital cost to install chemical injection systems and the annual cost of operating these systems, along with annual costs to inspect and clean (as necessary) water intake systems. Based upon the water utilities surveyed, the capital cost to install chemical injection systems with injection at a remote water intake averaged about $500,000 in mid-1990's dollars. Extrapolation of this capital cost across the 18 water supply systems using surface water yields a state-wide capital control cost of about $9,000,000.

Based on the water utilities surveyed, annual operating costs range from $5,000/year for diver inspection only, to about $50,000/year for chemicals and diver costs. Assuming average annual costs of $25,000/year across the 18 water systems yields a state-wide annual control cost of about $450,000.

continued

Electric Utility Surface Water Users

Steam electric generation using coal, natural gas or nuclear fuel uses surface water for many uses, including equipment and condenser cooling, fire protection and make-up for steam-cycle water. The highest volume use is for "non-contact" cooling, which uses surface water or recirculated cooling tower water to condense steam after passage through steam turbines. This non-contact cooling water passes through small diameter tubes in a condenser before discharge to the receiving water. Unhindered flow through these cooling water condensers is essential for efficient operation of the electric generating unit. Upon introduction into Lake Michigan and the Mississippi River, AIS zebra and later quagga mussels began colonizing the surfaces of cooling supply systems (intake structures, pipelines, pumps) and cooling water condenser tubes, resulting in electric generating units taken off-line for mechanical removal of mussels. Based on electric utility experiences on generating units on Lake Erie, which experienced problems with zebra mussels at least a decade earlier than Lake Michigan, Wisconsin utilities in the mid/ late 1990's installed chemical (biocide) and other forms of control (thermal, copper, other) to prevent AIS mussels from colonizing the miles of pipelines found in a modern steam-electric generating unit.

Since zebra and quagga mussels feed through filtering large volumes of surface water, an ancillary impact of AIS mussels in Lake Michigan is the removal of small plants and animals (plankton) normally found in the water, which subsequently increases water clarity. This increased water clarity results in increased growth of rooted plants and attached algae. Increased growth of a native group of algae in the genera *Ulothrix, Spirogyra* and *Cladophora* (collectively referred to as cladophora) and subsequent break-off from the bottom also negatively impacts utility use of Lake Michigan water due to the plugging of water intakes and systems.

Twelve of the 24 units (representing 4821 megawatts of 7472 megawatts or 64% of capacity) using Lake Michigan water susceptible to AIS problems were surveyed to develop an overview of control approaches and subsequent costs. Review of control approaches for generating units using Lake Michigan water shows that installation and use of biocide injection systems at the water intakes, and modifications to the water intake systems and other plant water systems were the most common approaches used to control both zebra and quagga mussels. The primary biocide used is chlorine, shown to prevent juvenile mussels from colonizing the surfaces of water systems. The chlorine is injected at the water intake on a continuous or intermittent basis, depending upon the severity of the mussel fouling potential in the area. Since zebra mussels are intolerant of warm water, some facilities use a thermal treatment approach to control mussels.

Since 1991, about $14,000,000 in capital expenditures were required at the twelve units surveyed to install chemical and other mussel control equipment. Extrapolation of these expenditures to the full population of units using Lake Michigan water yields an overall capital expenditure by electric utilities of about $28,000,000 (mid-1990's dollars). Not included in this total are expenditures made by utilities using Mississippi River water on the 1340 megawatts of generation located on that river system.

Annual operating and maintenance costs for the period 1991-2009 at the twelve units surveyed total $8,400,000 ($950,000/year), with lost generation costs, due primarily to the impacts of cladophora on plant systems costing about $6,000,000 ($700,000/year) over that same period. Extrapolation of these costs to the full population of units using Lake Michigan water yields annual operating and maintenance costs of about $1,900,000 and lost generation costs of about $1,200,000/year.

RESEARCH: Cost of potential regulations on the nursery industry and cost of pests *(Emerald Ash Borer and others)* to growers

Brian Swingle, *Executive Director of the Wisconsin Nursery Association and the Wisconsin Green Industry Federation*

The top Wisconsin commodities in rank order are: dairy, corn, soy, and nursery/horticulture. Tree and shrub wholesale production in 2004 was valued at $33,700,000 and all sales including resale were $123 million/year. Greenhouses generate $249,600,000/year in total sales. Christmas tree wholesale generates $22,700,000 in annual sales. The nursery industry feels the economic impacts of both regulations and pests that remove species from the trade as economically viable crops.

The value of species considered for regulation

The Wisconsin Nursery Association conducted a survey of its members to determine the potential cost to growers of regulating economically important species. This survey was completed with a 2010 specialty crop block grant (25% cost share) to give industry, the Species Assessment Groups who consider the species proposed for regulation under Wisconsin's Invasive Species Rule and the Department of Natural Resources the information on how to evaluate the impact of the rule on growers. This was confidential in that it protected individual growers' information. The survey was sent to 650 qualified growers to respond and there was a 45% return (295 surveys). The majority of the larger producers did respond. In looking at the values it is assumed that the impact is underestimated by half (Table 3).

Using several common examples, it takes about 5-6 years to grow popular street trees or shrubs to a saleable size. The investment for herbaceous plants is less but is still about 3 years. The industry can shift production to other species, but to reduce impact the preference is to phase out or develop a compliance period for moving stock out of the nurseries. A sudden implementation does not allow inventory to be cleared. Growers will typically remove species from inventory once there are complaints about them becoming invasive.

Table 3. Cumulative value of the top ten most valuable species being grow that were suggested for review as invasive species in 2011.

Common Name	Specific Name	Cumulative value	Rank
Norway maple	*Acer platanoides*	$1,515,063	1
Scots pine	*Pinus sylvestris*	$863,573	2
Winged euonymus	*Euonymus alatus*	$739,445	3
Japanese barberry	*Berberis thunbergii*	$653,885	4
Callery pear	*Pyrus calleryana*	$582,853	5
Amur maple	*Acer ginnala*	$470,745	6
Siberian elm	*Ulmus pumila*	$317,500	7
Miscanthus	*Miscanthus sinensis*	$235,013	8
Lesser periwinkle	*Vinca minor*	$200,125	9
Winter creeper	*Euonymus fortunei*	$170,218	10

continued

The cost of invasive species to growers

One of the worst pests of recent history is the Emerald Ash Borer. There were over forty ash cultivars being grown for landscaping and all more or less became unsalable once the pest arrived. Once Emerald Ash Borer was detected in Chicago, Mayor Daley stopped buying ash and the growers stopped investing in new trees. The loss depended both on the type of unit (size of tree being grown) and the number of units grown. There can be a loss of patient revenue due to growing specific cultivars. There was no insurance available so the costs were not recovered. As an example, a grower culled 4000 units leading to a $100,000 loss. The nurseries can switch to other trees but the investment in the stock is not recouped.

CASE STUDY: The impact of invasive species on the forest products industry, native communities and human communities in Wisconsin

Andrea Diss-Torrance, *Wisconsin Department of Natural Resources, Forestry*

It's hard not to find value in Wisconsin's forests. Some of the most valuable woods that Wisconsin exports are specialty products that have higher value; black walnut at the northern extent of its range has the densest growth, and figured maple is valued for furniture work. Ecotourism including forest recreation and fall foliage tours benefits cities in the areas where visitors arrive. Ecological services are harder to measure but include measurable benefits to the economy from hunting and clean water. In urban areas, landowners' property values also increase about $1000 per deciduous tree.

The Forestry program has a long history of working hard to protect these resources from pests. There are two categories of pest – those that cause catastrophic impacts and the pests that increase the costs of doing business. Examples of the first category include chestnut blight, beech bark disease and emerald ash borer. These pests remove the species that they attack from the areas they infest. Butternut canker is removing butternuts from economic viability and causing potential biological extinction as well. For these pests it is relatively easy to calculate trees that may go to economic extinction: black walnut is worth about $57,000,000. If emerald ash borer control fails, then there will be $371,000,000 in lost ash products. This loss of ash may be worse in urban areas because ash was used to replace American chestnut trees previously lost to chestnut blight. Increased costs will also fall on municipalities that are forced to remove trees to avoid additional damage to utilities. All told there could be about $2,400,000,000 overall damage from emerald ash borer in Wisconsin.

For species that increase the cost of products there can be high central control costs as well as the distributed costs to forest managers who have increased management costs across the lifecycle of the working forest. Asian longhorn beetle doesn't kill trees outright but it decreases the longevity of the trees and decreases the value of the maple lumber industry – about a $4,434,000,000 loss per year. This pest will increase the cost of maintaining the canopy in communities for a total cost of about $8,000,000. Invasive worms and invasive plants may increase costs to prepare planting sites and decrease the survival of young trees. Worms may also reduce the amount of soil carbon, reducing the value of the forest for carbon sequestration. It is obviously very difficult to calculate these costs.

continued

Can multiple species be prevented by one management option? A good example is firewood as this pathway moves multiple pests. Regulating the movement of firewood is relatively cheap compared to the values that are being protected.

There isn't funding available for all pests as the federal funds from the US Department of Agriculture are targeted at pests picked out for national importance. Some pests that have been federal priorities, receiving funds for the suppression of outbreaks, have been abandoned over short time leaving local efforts struggling to manage on their own. The public funds may be directed towards outbreak pests and move the public dollars towards pests that require widespread suppression to avoid harm or in investing in biocontrol which is not done by private individuals due to scale of effort required. Focus education by raising public awareness of the potential costs to their own resources.

GAPS: Focus on invasive species

Overall, specific economic studies of invasive species are a relatively small component of the economic research focusing on natural resources. Having an understanding of the scale of the impact is difficult simply because there are few studies that take on invasive species impacts at a national level. Encouraging research on invasive species by economists would greatly add to the discussion.

Some species such as sea lamprey have had careful cost benefit work done to determine the appropriate level of control to maintain valued resources, which in the case of the Great Lakes include trout and salmon. For most other widespread species that are causing well defined damage to valuable resources including crops, forests and biodiversity, there are very few studies available to help determine the appropriate level of control. As was noted in the opening, the use of economics to define the impact of invasive species may not give you the answer you want, but that in itself may be the start of conversation to better focus our limited resources for managing invasive species.

Wisconsin Invasive Species Council: http://invasivespecies.wi.gov
Wisconsin Department of Natural Resources: http://dnr.wi.gov keyword: "invasive"

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Bureau of Science Services
Wisconsin Department of Natural Resources
P.O. Box 7921, Madison, WI 53707-7921
Miscellaneous Publication PUB-SS-1113 2013

Funded, in part, by purchases of hunting and fishing equipment and motor boat fuels through the Federal Aid in Sport Fish and Wildlife Restoration programs.

PRINTED ON RECYCLED PAPER